Space Technology Research Grants

Structural Modifications of Continuous Aerogel Films for Low-power, High Performance Sensing Capabilities

Completed Technology Project (2013 - 2017)

Project Introduction

Recent work has found that TiO2 nanorods and nanowires can be grown from a high-surface area, highly porous TiO2 ambiently-dried aerogel structure through varying the gaseous atmosphere at elevated temperatures. Additionally, some nanowires were seeded by gold nanoparticles that remain at their tip, which in other systems has shown to enhance sensitivity and selectivity in metal oxide gas sensors. The proposed work seeks to improve the performance of current state-of-the-art metal oxide gas sensors by using a nano-engineered aerogel to generate a higher surface area, highly porous, nanocrystalline structure that can be precisely deposited onto a commercially-available, low-power microhotplate. The favorable regimes and mechanisms of nanoscale growth in TiO2 and SnO2 aerogel films will be examined in order to enable tailoring of the sensing structures. The sol-gel precursors will then be precision-deposited by an ink-jet printer onto a 200¼m x 200¼m microhotplate sensing platform. The resulting gel will then be post-processed into an aerogel film and structure modifications will be introduced as described above. The relationships between these structures and their resulting gas sensing properties will be carefully evaluated. Noble-metal nanoparticles and solid-solution doping will also be introduced to enhance analyte selectivity and enable low-temperature sensitivity in order to reduce power consumed by the heater element. This work will create highly sensitive, low-power gas sensors on a miniaturized device. Aerogel has shown excellent gas sensing properties, but has never been incorporated, into such a compact device. This work will be a key step toward enabling distributed sensing networks for continuous habitat and systems monitoring in spacecraft. Additionally, the demonstrated sensitivity of TiO2 to volatile organic compounds exhaled in a person's breath could lead to a handheld device capable of diagnosing and monitoring diseases and conditions that give off these organic compounds as markers in isolated outposts where heavy medical equipment is not available. Through the same mechanisms, TiO2 sensors could be used to detect organic, life-indicating compounds on Mars or other planetary bodies. The fundamentals of this research will also help to understand nanostructure development and modification in porous oxides. These advances could later be applied to dye-sensitized solar cells, photocatalytic water splitting, and photocatalytic oxidation for air revitalization, which all require highly-porous nanocrystalline TiO2 structures for efficient operations.

Anticipated Benefits

This work will create highly sensitive, low-power gas sensors on a miniaturized device. Aerogel has shown excellent gas sensing properties, but has never been incorporated, into such a compact device. This work will be a key step toward enabling distributed sensing networks for continuous habitat and systems monitoring in spacecraft. Additionally, the demonstrated sensitivity of TiO2 to volatile organic compounds exhaled in a person's breath could lead to a handheld device capable of diagnosing and monitoring diseases and

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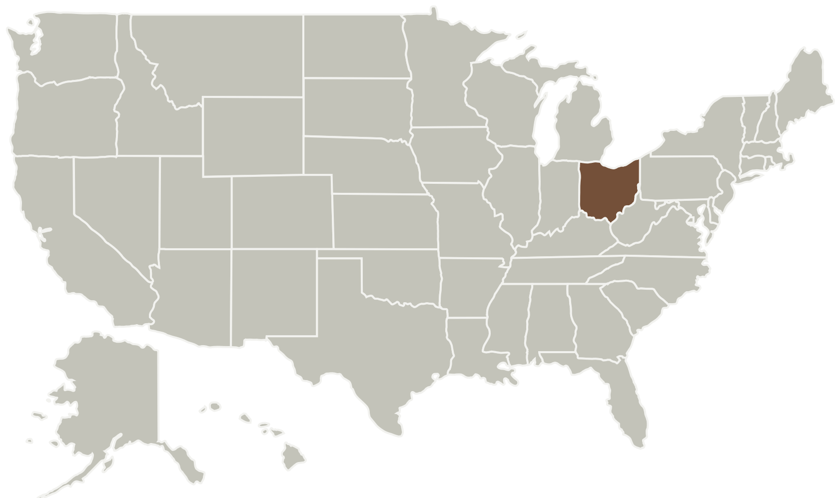
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Ohio State University-Main Campus	Lead Organization	Academia	Columbus, Ohio

Primary U.S. Work Locations
Ohio

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Ohio State University-Main Campus

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

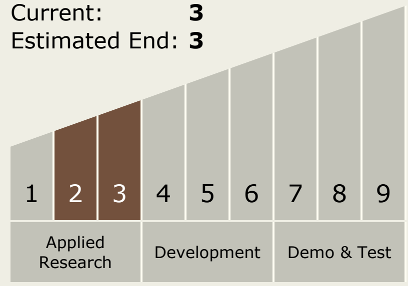
Patricia Morris

Co-Investigator:

Derek R Miller

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  └ TX12.1 Materials
    └ TX12.1.6 Materials for Electrical Power Generation, Energy Storage, Power Distribution and Electrical Machines

Target Destinations

The Moon, Mars, Others Inside the Solar System